Direct Seeded Irrigated Cropping Systems Instead of Burning

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GROWER ADVISORS: Neil Fink, Clark Kagele, Jeff Schibel, Gary Schell and Keith Schafer are deep-well irrigators in east-central Washington. John Aeschliman and Perry Dozier are dryland producers in the high-precipitation zone, and Ron Jirava in the low-precipitation zone, of eastern Washington. These growers actively encouraged the research and helped design the project. They serve as advisors throughout the life of the project.

OBJECTIVES: The objective of this long-term (6-yr) project is to determine the feasibility of direct seeding into high levels of residue as a substitute for burning in irrigated cropping systems. Specific objectives are to:

1. Test a 3-yr crop rotation of winter wheat - spring barley - winter canola. Crops are sown with a Cross-slot no-till drill into (i) standing stubble, (ii) after mechanical removal of stubble, and (iii) after burning the stubble. An additional treatment of annual winter wheat sown after stubble burning + moldboard plowing (sown with a double-disk drill) is included as a check.
2. Evaluate and develop effective techniques for planting crops into heavy surface stubble using no-till methods.
3. Document cumulative effects of a diverse no-till crop rotation under three stubble management practices on soil physical and biological properties, water use efficiency, diseases, weed ecology, and farm economics. Compare these effects to those under the check treatment (i.e., continuous winter wheat after stubble burning + moldboard plowing).

STATEMENT OF PROBLEM: Many deep-well irrigators in east-central Washington practice a continuous winter wheat rotation (i.e., grow winter wheat on the same field every year). Irrigated wheat grain yields range from 90-to 140-bushels per acre with residue production of 10,000 pounds or more per acre. After grain harvest in August, the traditional practice is to burn the stubble and invert the surface soil with moldboard plow tillage in preparation for planting in September. Generally, growers feel they need to burn their fields because high residue levels hamper planting. Alternatives to field burning are needed to reduce smoke emissions and maintain air quality. Another reason why irrigated growers burn and moldboard plow winter

wheat stubble is to control downy brome, a winter annual grass weed. Previous research has shown that long-term control of downy brome is very difficult in continuous irrigated winter wheat using no-till. Therefore, new crop rotation and stubble management strategies are needed to make no-till (without burning) work.

AGRONOMIC ZONE OF INTEREST: Irrigated. The research is also applicable to the high precipitation zone where cereal stubble after harvest may exceed 10,000 lb/acre.

ABSTRACT OF RESEARCH FINDINGS: We have now completed the first three years of a planned six-year irrigated cropping systems study at the WSU Dryland Research Station at Lind. The crop rotation is 3-year winter wheat - spring barley - winter canola sown *i*) directly into standing stubble, *ii*) after mechanical removal of stubble, or *iii*) after burning the stubble. The traditional practice of continuous annual winter wheat sown after burning and moldboard plowing is also included as a check treatment. There have been no within-crop grain yield differences as affected by residue management, except winter wheat in 2003 when the burn/plow treatment had significantly less yield due to Take All disease compared with no-till winter wheat in rotation. Stand establishment and weed control for all crops is almost always best in the burn treatment, but burning negatively affects over-winter precipitation storage efficiency. Green bridge carryover from volunteer barley caused serious disease pressure in winter canola seedlings which necessitated replanting to spring canola during two years. We have implemented a new planting method for winter canola to reduce green-bridge-related disease pressure. Annual testing of soil shows that soil quality in no-till plots is increasing rapidly compared with the burn/plow treatment. Over three years and across residue management treatments average grain yield was: winter wheat, 92 bu/a; spring barley, 2.48 t/a; and canola, 1971 lb/a. This study will continue for three more years.

MATERIALS AND METHODS: This study is conducted on 10 acres of cropland at the Washington State University Dryland Research Station at Lind. To obtain baseline residue levels to begin the experiment, the entire 10 acres was planted uniformly to Madsen winter wheat in September 1999. Grain yield (harvest August 2000) was 110 bu/a and straw production exceeded 10,000 lb/a.

Beginning in the 2001 crop year, a 3-yr crop rotation of winter wheat - spring barley - winter canola was grown under three stubble management methods. These methods are planting: *i*) directly into standing stubble, *ii*) after mechanical removal of stubble (i.e., after swathing and bailing), and *iii*) after burning of stubble. A check treatment of continuous annual winter wheat sown after stubble burning + moldboard plowing is also included. The experimental design is a modified split plot in a randomized complete block with four replications. Each portion of the 3-year no-till crop rotation in each stubble management method is sown each year. Thus, there are 40 plots (3 crops x 3 stubble management practices + the check continuous winter wheat x 4 replications).

A total of 15 inches of irrigation water is applied via hand lines to all crops each year. Six inches of water is applied after harvest in August. In the spring, three inches is applied in late April with the remainng six inches applied during the first week of June.

Seeding rates are 100, 100, and 7 lb/a, respectively, for 'Madsen' winter wheat, 'Baronesse' spring barley, and canola. Fertilizer rate is 120 lb N, 30 lb P, and 30 lb S per acre for all crops. No-till plots are planted and fertilized with a Cross-slot drill with notch-coulter openers on 8-inch row spacing. Continuous annual winter wheat in the burn/plow treatment is sown with a double-disk drill on 6-inch row spacing. In-crop broadleaf weeds in winter wheat and spring barley were controlled with 1.5 pints of Bronate per acre. Assure II herbicide is used to control grass weeds in canola.

RESULTS AND INTERPRETATION: The type of residue management (i.e., standing stubble, bailed stubble, or burned stubble) had a significant effect on plant stand, over-winter precipitation storage efficiency (SE), and weed population, - but not on grain yield (Table 1). The type of stubble (winter wheat, spring barley, or canola) also affected over-winter SE (Table 1). There were no residue management x crop interactions.

Table 1. Analysis of variance combined over three years for plant stand establishment, over-winter precipitation storage efficiency (SE), weeds, and grain yield as affected by residue management (standing, bailed, or burned) and crop (winter wheat, spring barley, and canola).

Source	df	Plant Stand	Precip. SE	Weeds	Grain Yield
Residue mgt. (R)	2	***	**	**	NS
Crop (C)	2	***	***	NS	***
R X C	4	NS	NS	NS	NS

,* Significantly different at the 0.01 and 0.001 probability levels, respectively.

Stand Establishment. Method of residue management had a highly significant ($P < 0.001$) effect on stand establishment of all crops during all three years (Table 2). Generally, the burn and burn/plow treatments had better and more uniform stands than the bailed stubble and standing stubble treatments, respectively (Table 2). The high levels of residue in the bailed stubble and standing stubble treatments was the cause for reduced stands compared with the burn and burn/plow treatments, however, stands were generally adequate in all treatments.

Over-winter precipitation storage efficiency. Water content to a depth of six feet was measured in all 40 plots at time of harvest in August and again in mid April. Burning of stubble significantly reduced over-winter precipitation storage efficiency (SE) in all crops during the 2001 crop year (Table 3). It is well understood that, under PNW conditions, the more residue on the soil surface the more water will be stored in the soil over winter. Although SE values among residue treatments were not significantly different during the 2002 and 2003 winters, the same trend of achieving greater water storage with more residue was apparent (Table 3), and the overall 3-year effect of residue on over-winter SE was highly significant ($P < 0.01$) (Table 1).

Table 2. Stand establishment (plants per square meter) of irrigated winter wheat, spring barley, and canola at Lind in 2001, 2002 and 2003 as affected by various stubble and soil management practices.

	Winter Wheat			Spring Barley			Canola		
	2001	2002	2003	2001	2002	2003	2001[A]	2002	2003[A]
Stubble burned	168 a	182 ab	212 b	185 a	172 a	177 a	84 ab	29 a	175 a
Stubble bailed	138 b	162 c	186 c	163 b	170 a	167 ab	87 a	19 ab	148 b
Standing stubble	109 c	177 b	190 c	156 b	156 b	157 b	76 b	15 b	144 b
Burn and plow	138 b	194 a	243 a						
P-Value	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Within-column means followed by the same letter are not significantly different.
A: spring canola planted in 2001 and 2003 when winter canola failed.

Table 3. Over-winter precipitation storage efficiency (SE) in 2001, 2002, and 2003 as affected by various stubble and soil management practices. Storage efficiency is the percentage of over-winter precipitation stored in the soil.

	Winter Wheat [A]			Spring Barley [B]			Canola [C]		
	2001 [D]	2002	2003	2001	2002	2003	2001	2002	2003
Stubble burned	47 b	23	38	65 b	44	64	56 bc	22	45
Stubble bailed	63 ab	28	46	83 a	48	67	71 ab	29	57
Standing stubble	73 a	22	37	85 a	38	57	75 a	34	50
Burn and plow	61 ab	21	35						
P-Value	0.004	NS	NS	0.003	NS	NS	0.003	NS	NS

[A] Winter wheat (in rotation) was planted into canola stubble except in 2001 crop year when all crops were planted into winter wheat stubble.
[B] Spring barley was planted into winter wheat stubble. The winter wheat stubble was burned after harvest in 2000, but was not burned until just before planting spring barley in April during the other years.
[C] Canola was planted into winter wheat stubble for the 2001 crop year but into spring barley stubble during the other years
[D] Within-column storage efficiency values followed by the same letter are not significantly different. NS = no significant differences.

Weeds. The main weeds in the experiment are Russian thistle, downy brome, prickly lettuce, and mare's tail. Weed population and dry biomass production are determined in each plot within a 3- square-meter area just before grain harvest. Method of residue management has had a highly significant effect on weed populations ($P < 0.01$) (Table 1). Populations of the four main weed species in all residue and crop treatment combinations in 2001, 2002, and 2003 are shown in Table 4A, 4B, and 4C, respectively. Note the differences in all weed species among treatments in 2001 (except for mare's tail) and 2003, but not in 2002 when weed population among

treatments was the same. The three-year average shows no overall difference in prickly lettuce and mare's tail populations as affected by crop or residue management treatment, but there were highly significant differences for Russian thistle and downy brome (Table 4D). Overall, Russian thistle was the biggest problem in canola whereas the highest populations of downy brome were generally measured in winter wheat planted into bailed and standing stubble (Table 4D).

Grain Yield. Within the no-till residue management treatments, there has been no grain yield differences in any crop in any year or when averaged across years (Table 1, Table 5). This shows that crops have successfully compensated for differences in plant stands. The only significant grain yield difference occurred in 2003 when continuous winter wheat using burn/plow resulted in a yield of only 74 bu/a, - significantly less than any of the no-till winter wheat plots (Table 5). The low yield in continuous winter wheat using burn/plow was due to Take All disease.

Outreach: Field Days, Presentations, and Advisory Meetings
This project was shown and discussed to numerous groups and individuals during the past three years. Some of these events are listed below:

Event	Date	Attendance
Grower-researcher advisory, Lind	March 7, 2000	17
Grower program, Ritzville	February 7, 2001	80
Lind Field Day	June 14, 2001	160
PNW Direct Seed Assoc. meeting, Lind	June 27, 2001	15
Grower-researcher advisory, Lind	November 20, 2001	14
Oilseed Crop Research Forum, Moscow	March 4, 2002	55
Lind Field Day	June 13, 2002	175
Quality of Life Tour, Lind	June 26, 2002	45
Great Plains no-till group, Lind	October 23, 2002	5
Grower-researcher advisory, Lind	November 26, 2002	13
Far West Fertilizer Conference, Spokane	December 10, 2002	85
STEEP Research Review, Pasco	January 7, 2002	90
Grower program, Ritzville	February 5, 2003	60
Lind Field Day	June 12, 2003	177
National Soil Water Cons. Soc. Students, Lind	July 29, 2003	27
Wash. Pest Consultants Ann. Meeting, Yakima	November 13, 2003	30
Grower-researcher advisory, Lind	November 25, 2003	12

The Next Three Years. We have now completed one full cycle of the three-year rotation. This experiment will be conducted for another three years. Several publications involving agronomy, soil quality, economics, and plant pathology are envisioned upon completion of the six-year project in 2006. The authors thank the grower advisors for the considerable time and effort they devote to this project.

Table 4. Population of four weed species in irrigated winter wheat, spring barley, and canola in 2001 (A), 2002 (B), 2003 (C), and the three-year average (D) as affected by residue management.

A. 2001		Weeds (per 3 m^2)			
Crop	Residue Management	Prickly Lettuce	Mare's-Tail	Russian Thistle	Downy Brome
Winter Wheat	Burn/Plow	0 b	0	1 b	1 b
Winter Wheat	Burned	0 b	0	0 c	0 b
Winter Wheat	Bailed	0 b	0	0 c	18 a
Winter Wheat	Standing	0 b	0	1 b	10 a
Spring Barley	Burned	0 b	0	0 c	0 b
Spring Barley	Bailed	0 b	0	0 c	0 b
Spring Barley	Standing	0 b	0	0 c	0 b
Winter Canola	Burned	0 b	10	3 a	0 b
Winter Canola	Bailed	1 a	19	0 c	0 b
Winter Canola	Standing	2 a	5	3 a	0 b
		***	NS	**	***

B. 2002		Weeds (per 3 m^2)			
Crop	Residue Management	Prickly Lettuce	Mare's-Tail	Russian Thistle	Downy Brome
Winter Wheat	Burn/Plow	0	0	0	0
Winter Wheat	Burned	5	18	0	1
Winter Wheat	Bailed	3	14	0	5
Winter Wheat	Standing	4	7	0	2
Spring Barley	Burned	7	2	0	0
Spring Barley	Bailed	12	7	0	0
Spring Barley	Standing	5	5	0	0
Winter Canola	Burned	2	4	0	0
Winter Canola	Bailed	5	3	0	0
Winter Canola	Standing	3	1	3	0
		NS	NS	NS	NS

C. 2003

Crop	Residue Management	Weeds (per 3 m^2) Prickly Lettuce	Mare's-Tail	Russian Thistle	Downy Brome
Winter Wheat	Burn/Plow	0 c	1 a	1 b	0 b
Winter Wheat	Burned	0 c	0 b	0 b	0 b
Winter Wheat	Bailed	0 c	0 b	0 b	28 a
Winter Wheat	Standing	0 c	0 b	0 b	15 a
Spring Barley	Burned	0 c	0 b	0 b	0 b
Spring Barley	Bailed	0 c	0 b	0 b	0 b
Spring Barley	Standing	0 c	0 b	0 b	0 b
Winter Canola	Burned	1 bc	0 b	3 b	0 b
Winter Canola	Bailed	4 a	1 a	10 a	35 a
Winter Canola	Standing	2 ab	1 a	10 a	1 b
		***	***	***	**

D. Three-year average

Crop	Residue Management	Weeds (per 3 m^2) Prickly Lettuce	Mare's-Tail	Russian Thistle	Downy Brome
Winter Wheat	Burn/Plow	0	1	1 bc	0 c
Winter Wheat	Burned	2	6	0 c	1 bc
Winter Wheat	Bailed	1	5	0 c	17 a
Winter Wheat	Standing	1	2	0 c	9 ab
Spring Barley	Burned	2	1	0 c	0 c
Spring Barley	Bailed	4	2	0 c	2 bc
Spring Barley	Standing	2	2	0 c	1 bc
Winter Canola	Burned	1	1	2 ab	0 c
Winter Canola	Bailed	3	2	4 a	12 a
Winter Canola	Standing	3	1	4 a	0 c
		NS	NS	***	***

Within-column means followed by the same letter are not significantly different. *, **, *** Significantly different at the 0.05, 0.01, and 0.001 probability levels, respectively. NS = no significant differences.

Table 5. Grain yields of irrigated winter wheat, spring barley, and canola at Lind in 2001, 2002 and 2003 as affected by various stubble and soil management practices.

	Winter Wheat (bu/a)			Spring Barley (ton/a)			Canola (lb/a)		
	2001	2002	2003	2001	2002	2003	2001[A]	2002	2003[A]
Stubble burned	85	106	113 a	2.88	2.21	2.39	2574	2502	1027
Stubble bailed	67	110	96 a	3.03	2.33	2.24	2486	2226	1135
Standing stubble	69	107	101 a	2.88	2.26	2.08	2282	2188	1326
Burn and plow	75	97	74 b						
LSD (0.05)	NS	NS		NS	NS	NS	NS	NS	NS

Within-column wheat yields in 2003 followed by the same letter are not significantly different $P < 0.05$.
NS = no significant differences.
A: spring canola planted in 2001 and 2003 when winter canola failed.

PUBLICATIONS (2003 only):

Published Abstracts

Schafer, H.L., W.F. Schillinger, B.E. Sauer, A.C. Kennedy, and T.C. Paulitz. 2003. Direct seeding into heavy residue of irrigated crops as an alternative to burning. Soil and Water Conservation Society annual meeting, 28-31 July, Spokane, WA. *SWCS Annual Conf. Abstracts*, p. 53.

Experiment Station Research and Extension Reports

Schillinger, W.F., H.L. Schafer, B.E. Sauer, A.C. Kennedy, and T.C. Paulitz. 2003. Alternative to burning. p. 30. *In* 2003 Field Day Abstracts: Highlights of Research Progress. Dept. of Crop and Soil Sciences Tech. Report 03-2, WSU, Pullman, WA.

Kennedy, A.C., T.L. Stubbs, W.F. Schillinger, and J.C. Hansen. 2003. Soil quality changes with no-till management adoption for wind erosion control. p. 29. *In* 2003 Field Day Abstracts: Highlights of Research Progress. Dept. of Crop and Soil Sciences Tech. Report 03-2, WSU, Pullman, WA.

Paulitz,T.C., W. Schillinger, and R.J. Cook. 2003. Root diseases in the irrigated crop residue management study at Lind. p. 26. *In* 2003 Field Day Abstracts: Highlights of Research Progress. Dept. of Crop and Soil Sciences Tech. Report 03-2, WSU, Pullman, WA.